Electrical Infrastructure Research Team

Cable and Connector Requirements

August 5, 2014

1) Sections

- Areas of Focus
- Team Members for Feedback
- Electrical Characteristics
- Cable Jacket and Connector Molding Materials
- Connector Style Options
- What we've developed to date
- Next Steps

2) Areas of Focus

- Circuits to Consider – All LED Lighting
- Primary Focus – Phase 1
  - Taxiway Edge
  - Taxiway Centerline
  - MIRLs and HIRLs
  - Runway Centerline
  - TDZs
- Secondary Focus – Phase 2
  - Threshold
  - Signs
  - REILs

3) Team Members for Feedback

- Gene Gottlieb (ORD)
- Frank Barczak / Jeff Pace (MCO)
- Rick Meyers (SLC)
- Dave Reeves (MEM)
- Chris Davis (ATL)
- Jim Evans (CLT)
- Dave Pracht / Heather McKee (DIA)
- Mark Borrough (SEA)
- Dave Garrett (DTW)
- Mike Bowman / Frank Slusher (IAD)
- Jay Dupont (PHX)

3) Team Members for Feedback

- How to use Team:
  - Feedback early on for chemical interaction in the field
  - Comments on what they want with ideal cable and connectors and why
  - Sample testing in the field
  - Feedback in setting up testing requirements
- New members for consideration
  - Adam Zandan – Prysmian / Draka Cable
  - Ben Goebel – Atkins Engineer
  - Carl Johnson – Avcon
- Why this is important
  - Will assist FAA in developing specifications with input from field
  - Input from experts who handle product daily

4) Electrical Characteristics

- Legacy Mode Option
  - Ability to go back to legacy mode
  - 6.6A at 5KV on primary, 6.6A at 600V on secondary

- Future Only Options
  - Get VA for each manufacturers LED lights (see matrix) - Confirm
  - Get layout detail – how many lights are typical for each area.
  - Calculate estimated losses
  - Excel spreadsheet for VA requirements
  - Resistance, Efficiency other considerations factored in
  - Find max requirement – spec cable and connector ratings to meet max requirements – create buffer (load calc target at 70%)

Manufacturer	Part # (Depends on color, power, height, arctic option, etc.)	Description	Arctic Option	Amps	VA
ADB	L861T (L): ETES-XXXX	**Elevated Taxiway Edge Light**	W/O Heater (or Heater off)	6.6	12
			W/ Heater	6.6	25
	L850A (L): IRCL-XXXXXX	**LED Runway Centerline**			
		Unidirectional	W/O Heater		15
		Bidirectional- One Cord Set	W/O Heater		29
		Unidirectional	W/ Heater		30
		Bidirectional- One Cord Set	W/ Heater		59
	L850B (L): TDZL-XXXXX	**Style 3 LED Touchdown Zone Light**	W/O Heater		15
			W/ Heater		30
	L850C (L) and L850D (L): IREL-XXX0XXX	**Style 2 LED Runway Edge and Runway Threshold and Runway EndLight**			
		Unidirectional	W/O Heater		21
		Bidirectional-One Cord Set	W/O Heater		36
		Unidirectional	W/ Heater		49
		Bidirectional-One Cord Set	W/ Heater		64
	L852A/B/C/D (L) and L852J/K (L): ITCF-XX0XXX	**F-Range LED Taxiway Centerline Light**			
		L852D (L), L852K (L)			
		Unidirectional	W/O Heater		21
		Bidirectional-One Cord Set	W/O Heater		27
		Unidirectional	W/ Heater		56
		Bidirectional-One Cord Set	W/ Heater		58
	L852T (L): ITEL-XXXX	**Style 3 LED Taxiway Edge Light**	W/ Heater	6.6	44
			W/O Heater	6.6	19.5
	L862 (L) and L862E (L): EREX-XXXX-XXX-0000	**LED Runway Edge High Intensity Bidirectional Elevated Light**	N/A	2.8-6.6	32

CHALP	TEL- L861 (L): 8 6 1 5 – T 5 – B – 0 6 6	**Omnidirectional Taxiway Edge Light- LED**	W/O Heater	6.6	11.2
			W/ Heater	6.6	30
	Pro V RCL/TDZ-LED, L850(L): 850X-5-XX-F1-XXX-XX-X	**Runway Centerline Light**			
		Unidirectional White	W/O Heater	6.6	21
		Unidirectional Red	W/O Heater	6.6	11
		Bidirectional White/White	W/O Heater	6.6	42
		Bidirectional White/Red	W/O Heater	6.6	33
		Unidirectional White	W/ Heater	6.6	35
		Unidirectional Red	W/ Heater	6.6	25
		Bidirectional White/White	W/ Heater	6.6	70
		Bidirectional White/Red	W/ Heater	6.6	61
	Pro V TCL-LED, L852(L): 852X-5-XX-F1-XXX-XX-X	**Taxiway Centerline Light**			
		Unidirectional C and K	W/O Heater	6.6	12
		Bidirectional C and K	W/O Heater	6.6	24
		Unidirectional D	W/O Heater	6.6	13
		Bidirectional D	W/O Heater	6.6	26
		Unidirectional C and K	W/ Heater	6.6	26

4) Electrical Characteristics

- Have completed research
- Looking at one option for 10A at 2,000V
- NEC benefit of cable under 2500V – shielding not required if under 2500V
- Focus now on jacket construction

- Discussions on handling of Arctic (Heater) Kits:
  - Kick on automatically at 40F or under
  - LED load and Heater load on same isolation device – good idea going forward?

5) Jacket and Molding Materials

- Have list of about 10 chemicals and elements to consider
- (See Attached) Need to Finalize List
- Got MSDS for each chemical / element
- Visit 2 or more chemists for compounding and / or cable processing companies
- Open up project to find right cable jacket material
- Open up project to find right connector molding material

5) Jacket and Molding Materials

Primary

- Water
- Salt
- Dielectric Grease
- Potassium Acetate
- Jet Fuel
- Glycol
- Urea – Diesel Exhaust
- P605 and P606 Sealant
- Asphalt Rejuvenator
- Grass Fertilizer
- -50F to 200F

Secondary

- Fire Ant Powder and Spray
- Hot Sand / Grit
- Rodents – chew / pee
- Weed Killer

5) Jacket and Molding Materials

- Findings:
- Best Materials for molded connectors and cable jacket
  - Santoprene
  - Sarlink
  - Evaprene

To improve Insulation Resistance:

- Increase the thickness of jacket on primary cable

- Increase the thickness of wall size for in field connections

6) Cable Performance

- **Tolerance – most important (one size with tight OD tolerance – will be important for connector sizing)**
- Jacket thickness minimum (needs to fit 1” ID conduit)
- Bend Radius
- Insulation Resistance
- Temp rating
- Abrasion Resistant
- Need to understand cost impact
  - Life Cycle cost savings study

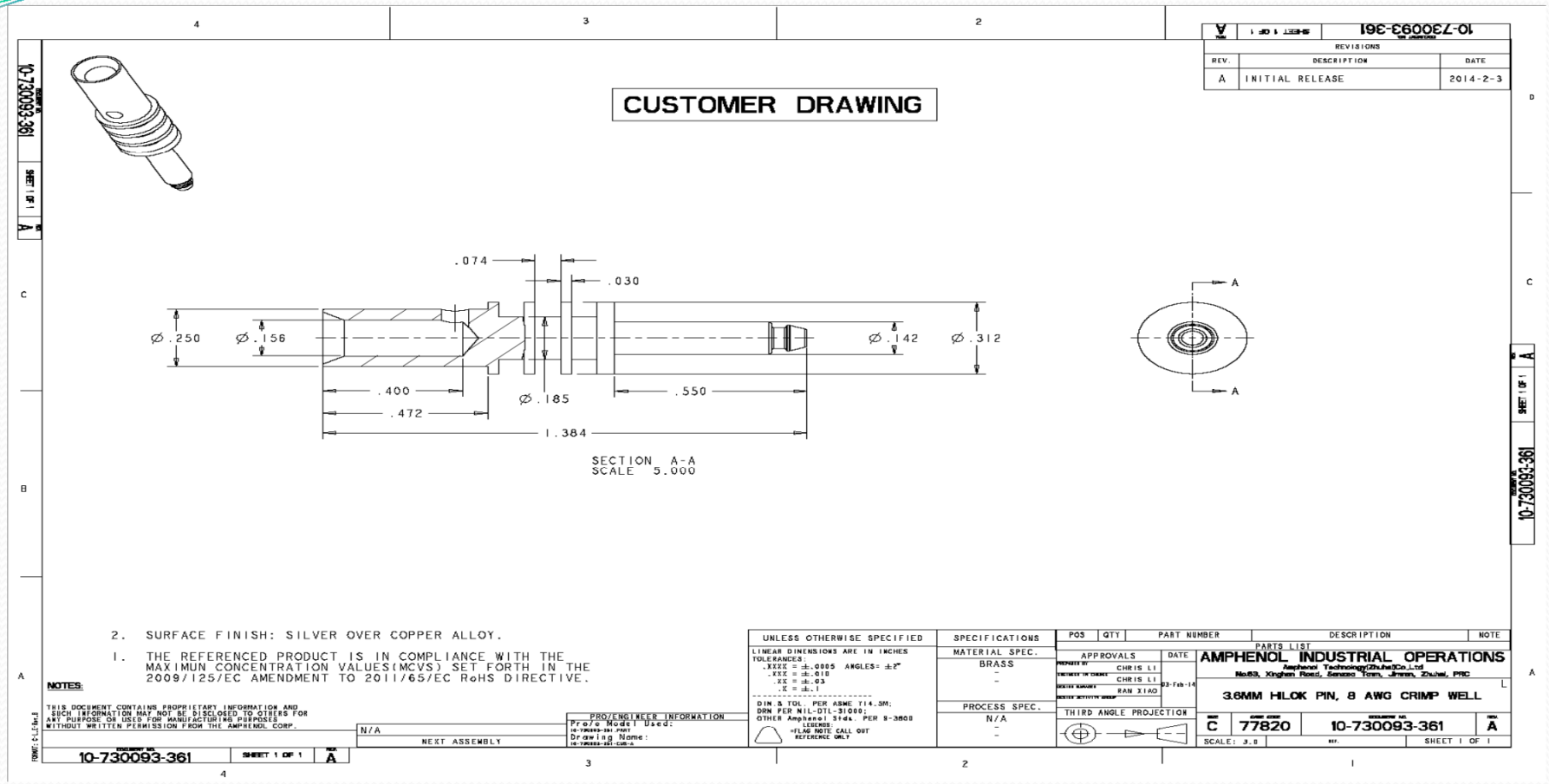
6) Cable Performance

- Increase cable jacket thickness – set standard for OD
  - Std is around 0.350" now
  - Looking for 0.400" or so
  - Will test to see impact via adding more material – optimal point – do not anticipate much cost impact
  - Tolerance is +/- 0.10"
- Bend Radius – 1.5" Radius
  - How far into connector does it create bulge
  - Coordinate bend relief in connector with bend radius

7) Contact Options

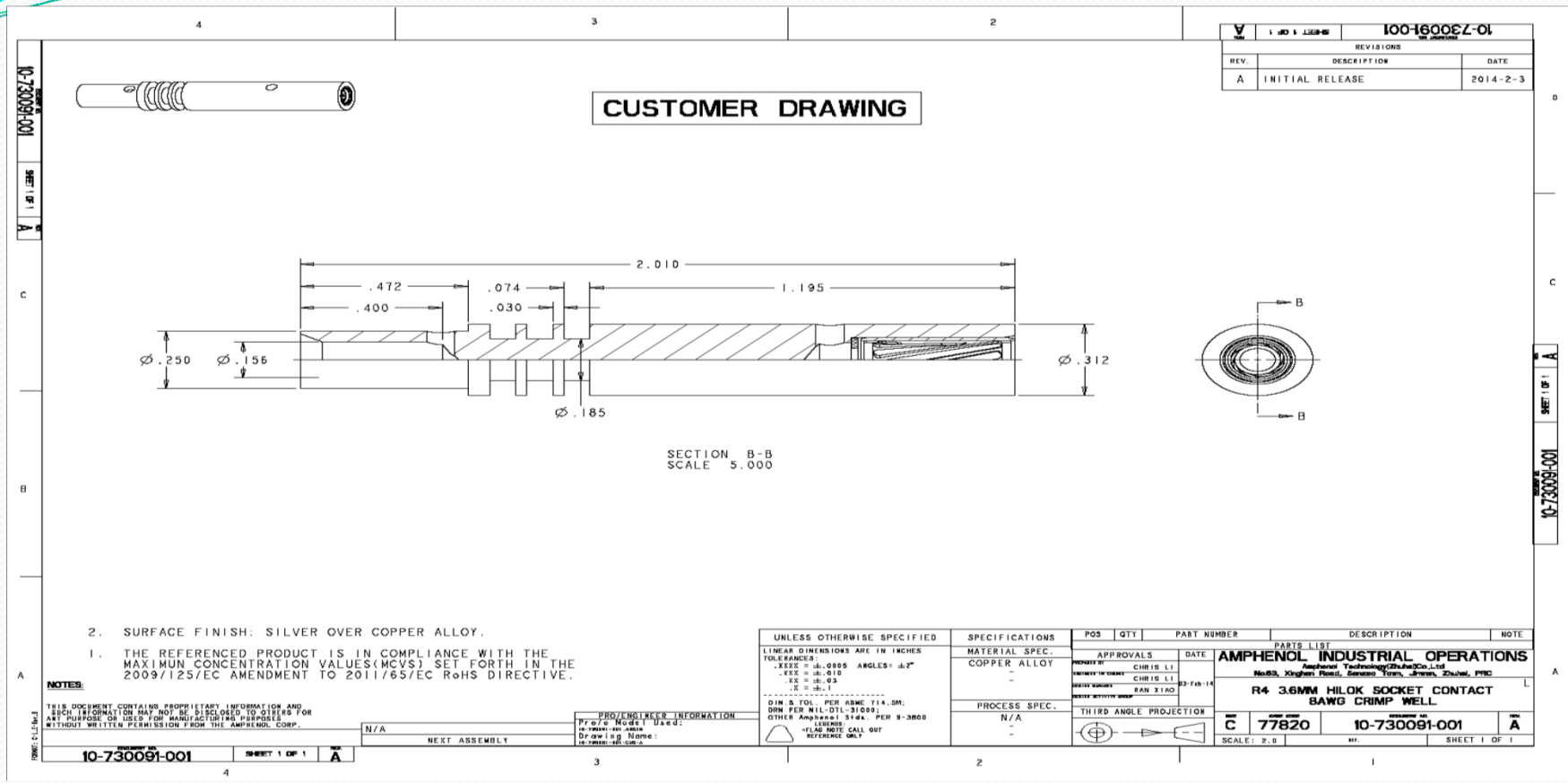
- Brass Contacts
  - Amphenol Rad Sock is perfect
  - Ballpark price quote is not excessive
  - The best I've seen for positive contact at 100% of brass connection
  - Keep brass for best conductivity
    - Leave Male Connector relatively the same
    - Improve female connector with rifle design
  - Recommend same plating and chemical treatment for corrosion resistance
  - Incorporate 3 anchors for each contact to lock into insulator better and raise height of them

Male Primary Pin



- Locking Feature on Cap
- Multiple anchors for better snap in grip on inside of connector
- Hole for screw down / and crimp option (need to test)

Female Primary Contact



- Rifle Design
- Lock in point at base for cap
- Hole for screw down / and crimp (need to test)
- Multiple Anchors

8) Connector Options

- Housing Design – Primary
  - Connector with ribs and ridges for excellent handling while assembling
  - Connector locks into place when assembled correctly, positive cue (better design than current anchor system)
  - Design with flat – one way in, one way out
- Prevent Water Ingress
  - Mating design will continue to be 20 psi or more
  - Pull test for mating no longer an issue
  - Better control of water ingress on back side
    - Tighter cable tolerance
    - Better Control on assembly
    - Utilize superior design characteristics

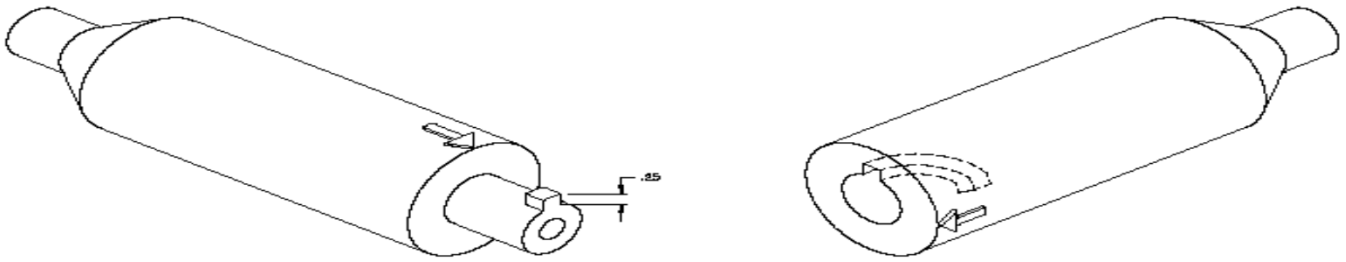
8) Connector Options

- Cut Outs in interior of connector for 2 anchors to engage
- Key molded on male for Dinse style locking into female
  - Key will be ¼" high molded in same material
  - Push in – twist – lock back into place
- Wall thickness of connectors increased to 0.650"
  - Overall connector thickness to 1.7" or so
  - Got specs on molding material and calculate IR improvement per every 0.005" of material density – found ideal thickness

8) Connector Options

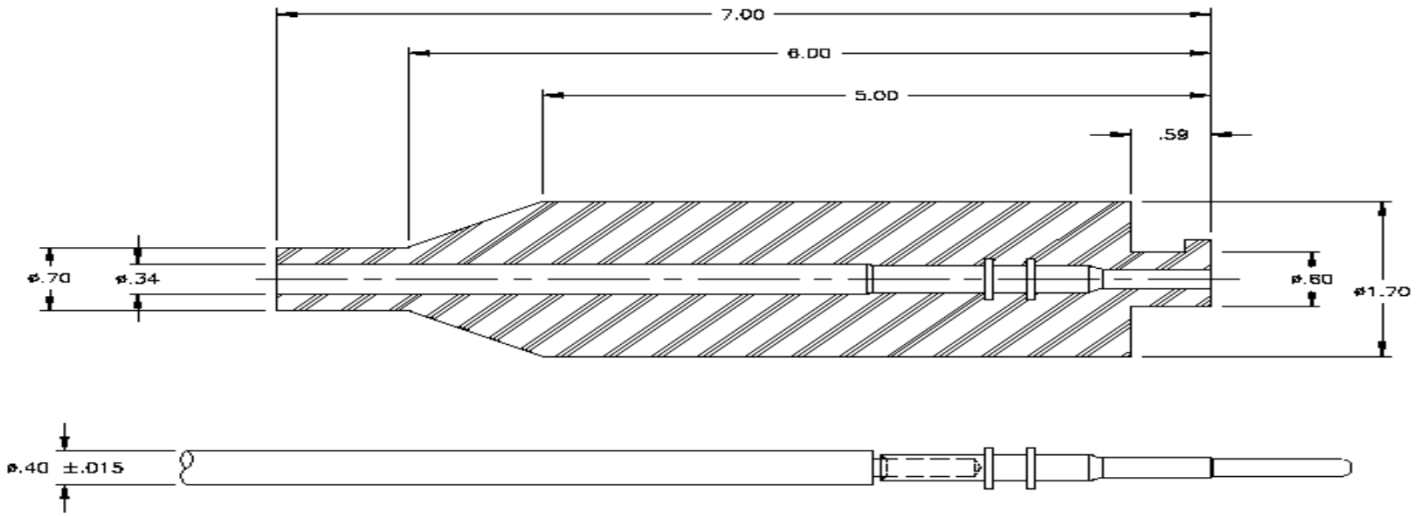
- Bend Relief
  - Assume cable nominal = 0.400” and wall thickness for connector is 0.650” for 1.700” OD of connector
  - Bend Relief is 2” long
  - This will guarantee the cable goes straight into the connector and bend will be absorbed beforehand
- First inch from back of connector
  - Tapers on an angle from 1.700” OD to 0.700” OD
  - This will absorb all the bend
- Second inch from back of connector
  - Same thickness throughout at 0.170”
  - Flexible to grab cable and give a good seal
  - Set ID at 0.340” for good interference fit

Male / Female Insulators – Keyed Approach



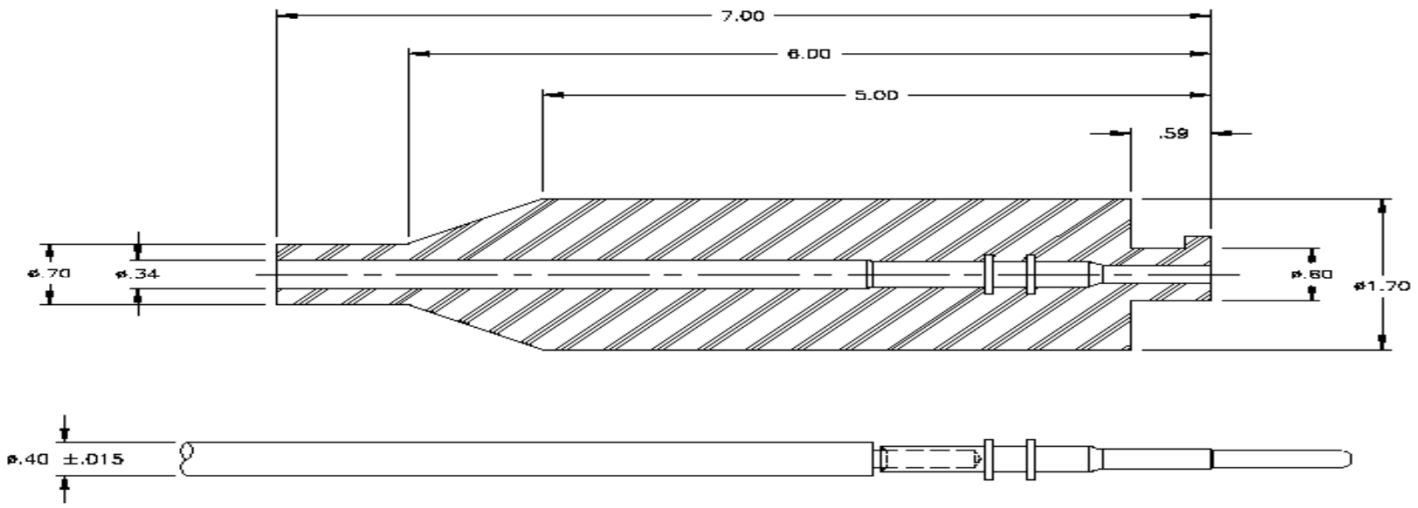
-Molded Key on male insulator
- ¼” high for good grab with 65 durometer material
- Female channel to lock part in place after successful installation

Connector Dimensions



- Wall Thickness increased to 0.65” on each side
- Overall OD increased to 1.7”
- More material to withstand elements
- Developed Bend Relief into the part

Connector Dimensions



- On back of connector, 1st inch taper from 1.7" to 0.7"
- On back of connector, 2nd inch maintain same thickness at 0.7"
- Starting ID 0.34" similar durometer
- Good interference fit with wall expansion on last inch – like tape
- Good compaction in second inch

9) Next Steps

- 1) Prototype Concepts
- 2) Lab Test for Performance
- 3) Use team to test at controlled areas of major airports
- 4) Consolidate test data – meet to understand
- 5) Adjust designs as necessary
- 6) Report Findings to FAA

10) Questions and Answers

- Thank you for your time and attention!

- John Bogart
- President, Integro